Supplementary Information

Improving electrical memory performance of pyrazoline moiety *via* the preparation of its hyperbranched copolymer

Caijian Lu,^a Quan Liu,^a Peiyang Gu,^a Dongyun Chen,^a Feng Zhou,^a Hua Li,^a Qingfeng Xu^{*a} and Jianmei Lu^{*a}

^a College of Chemistry, Chemical Engineering and Materials Science, Collaborative Innovation Center of Suzhou Nano Science and Technology, Soochow University, 199 Ren'ai Road, Suzhou 215123, China.

Synthesis and characterization of HPPS-1 and HPPS-2

Styrene (8 or 16 mmol), BrATPP (0.2 mmol), CuBr (0.02 mmol) and PMDETA (0.04 mmol) were dissolved in cyclohexanone and the mixture was placed into a two-neck round-bottomed flask. The flask was sealed and cycled between vacuum and Ar (g) three times. The polymerization was conducted at 100 °C for 5 h and stopped by quenching the flask in ice water. After dilution with DMF, the diluted solution was passed through an alumina column to remove the copper catalyst, and the filtrate was precipitated by addition of ethanol. The crude polymers were purified by Soxhlet extractor with ethanol to remove excess monomers to get HPPS-1 and HPPS-2 and their ¹H NMR spectrum were shown in Fig. S4, S5. GPC showed the the number-average molecular weight (*Mn*) of HPPS-1 was about 8750 g mol⁻¹ with the polydispersity index (PDI) of 2.20, while the *Mn* of HPPS-2 was about 9900 g mol⁻¹ with the PDI of 1.72.



Fig. S1-1¹H NMR spectrum of 4-(1,3-Diphenyl-4,5-dihydro-1*H*-pyrazol-5-yl)-N,N-dimethylaniline (ATPP).



Fig. S1-2¹³C NMR spectrum of 4-(1,3-Diphenyl-4,5-dihydro-1*H*-pyrazol-5-yl)-N,N-dimethylaniline (ATPP).



Fig. S2-1 ¹H NMR spectrum of 2-(methyl(4-(1-phenyl-3-(4-(4-vinylbenzyloxy)phenyl)-4,5dihydro-1*H*-pyrazol-5-yl)phenyl)amino)ethyl 2-bromo-2-methylpropanoate (BrATPP).



Fig. S2-2 ¹³C NMR spectrum of 2-(methyl(4-(1-phenyl-3-(4-(4-vinylbenzyloxy)phenyl)-4,5dihydro-1*H*-pyrazol-5-yl)phenyl)amino)ethyl 2-bromo-2-methylpropanoate (BrATPP).



Fig. S3 ¹H NMR spectrum of hyperbranched polystyrene (HPPS, 18.8% BrATPP).



Fig. S4 ¹H NMR spectrum of hyperbranched polystyrene (HPPS-1, 13.0% BrATPP).



Fig. S5 ¹H NMR spectrum of hyperbranched polystyrene (HPPS-2, 4.36% BrATPP).



Fig. S6 (a) Absorption spectra of BrATPP at different concentrations and HPPS, HPPS-1 and HPPS-2 at 50.000 mg/L. (b) Calibration curve for determining the content of HPPS, HPPS-1 and HPPS-2, using BrATPP as standard.

To determine the weight percentage of BrATPP in the copolymers HPPS, HPPS-1 and HPPS-2, the absorption spectra of BrATPP at different concentrations and the calibration curve were measured, as shown in Fig. S6. We choose the absorption values at the maximum absorption peak (λ_{max}) of BrATPP as the Y, and the corresponding concentration values as the X to obtain the linear regression equation:

 $Y = 0.01607 + 0.06298 X, R^2 = 0.9998$

where Y is the absorbance of BrATPP at 358 nm, X is the concentrations of BrATPP (mg/L) and R^2 is linearly dependent coefficient. The value of R^2 is very close to 1.000, which indicates that the data points have good linear characteristic. From the linear regression equation and the absorbance values at 358 nm of copolymers, we determined that the weight percentage of BrATPP in HPPS, HPPS-1 and HPPS-2 was 18.8%, 13.0% and 4.36%, respectively.



Fig. S7 TGA curves of (a) ATPP and (b) HPPS collected under N_2 at a scanning rate of 10 °C/min.



Fig. S8 I-V curves of the device ITO/ATPP (70 nm)/Al at the compliance current of 0.1 A.



Fig. S9 Cross-sectional SEM images of ITO/ATPP (30 nm)/Al device and ITO/ATPP (120 nm)/Al device.



Fig. S10 Typical I-V curves of the device ITO/ATPP (30 nm)/Al at compliance currents of (a) 0.1 A and (b) 0.001

A.



Fig. S11 Typical I-V curves of the device ITO/ATPP (120 nm)/Al at compliance currents of (a) 0.1 A and (b) 0.001 A.



Fig. S12 Cross-sectional SEM images of ITO/HPPS (30 nm)/Al device and ITO/HPPS (140 nm)/Al device.



Fig. S13 Typical I-V curve of the device ITO/HPPS (30 nm)/Al at the compliance current of 0.1 A.



Fig. S14 Typical I-V curves of the device ITO/HPPS (140 nm)/Al at the compliance current of 0.1 A.



Fig. S15 Typical I-V curves of the device ITO/HPPS-1/Al at the compliance current of 0.1 A.



Fig. S16 Typical I-V curve of the device ITO/HPPS-2/Al at the compliance current of 0.1 A.



Fig. S17 UV-vis absorption spectra of the ATPP film onto ITO substrate before and after experiencing Hg-droplet

experiments.